EXHIBIT 2

Microelectronic Grade Silicone Materials for CSP

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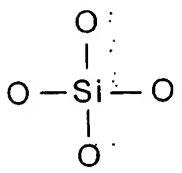
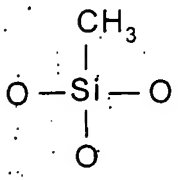
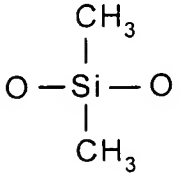
Outline

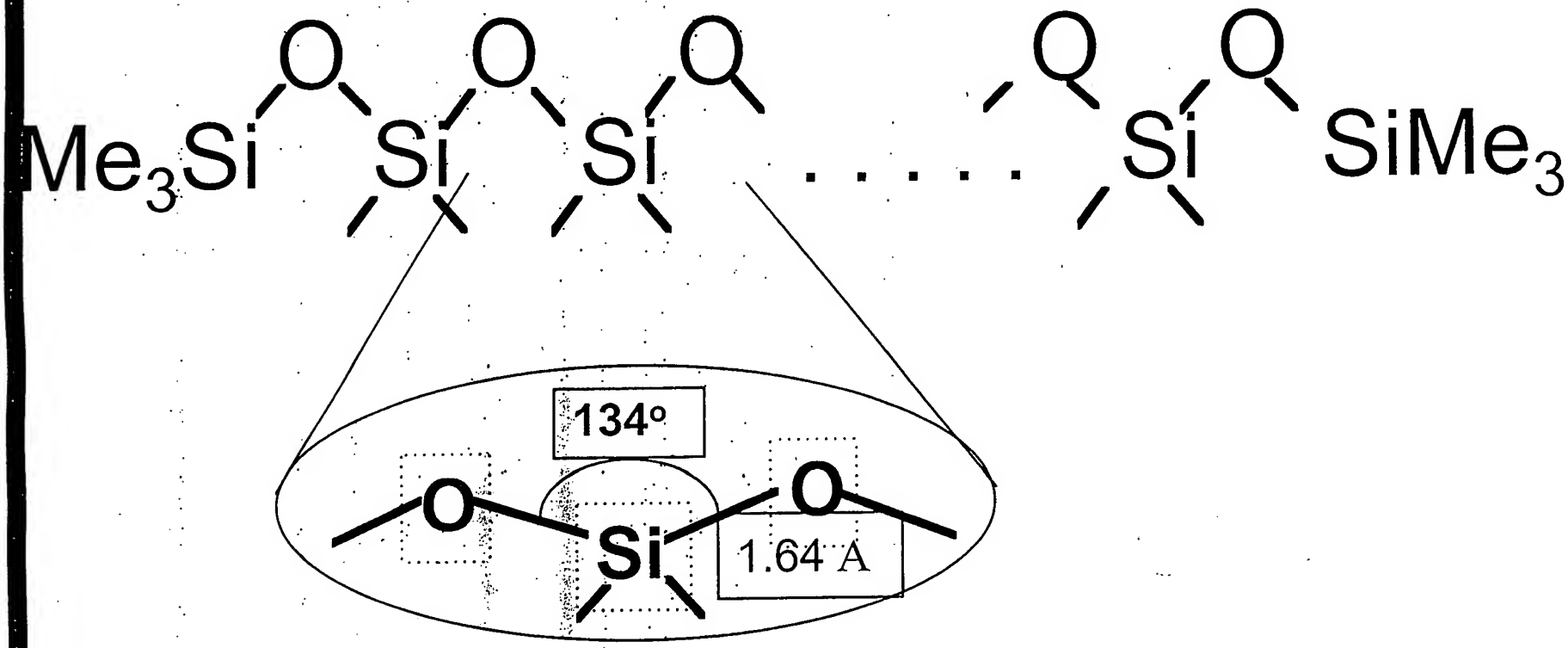
- The nature of silicones
- Silicone polymerization
- Root cause of silicone outgassing
- Development of materials for use in the μBGA package
  - Resolution of Lead bond issues
  - X-ray Photoelectron Spectroscopy images
- Conclusions

Chemical Nature of Silicones

Degree of Alkyl Substitution

0	1	2
		
SiO_2	$R_1SiO_{3/2}$	R_2SiO
Silica	Silicone resins	Silicone
Glasses	Silsesquioxanes	polymers
Hard & Brittle		**Soft & Flexible**

Properties of Silicone Fluids



- Wide OSiO angle ⟹ Free rotation, low Tg, Tm, etc
- Strong Si-O Bond ⟹ High Thermostability
- PDMS backbones are covered by CH_3's, hydrophobicity

Silicone Properties*

- Liquid at high molecular weight
- Low apparent activation energy for viscous flow
- Low surface energy
- High gas permeability
- High dielectric strength
- Thermal stability
- Oxidative resistance
- Low boiling points
- Excellent flammability properties
- Low surface shear viscosity

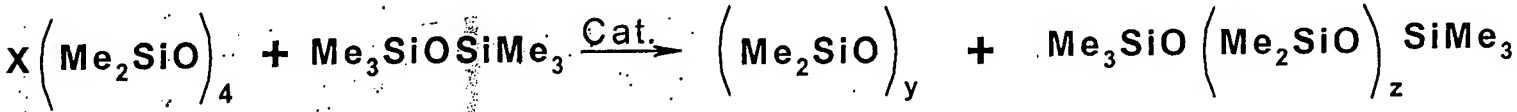
* Relative to hydrocarbon materials

Equilibration Polymerization of Silicones

- Acid or base catalysis
- Time, temperature and solvent effects
- Molecular weight control
  - End block
    - trimethylsilyl
    - dimethylhydroxyl
    - dimethylvinyl
    - others

Equilibration Polymerization of Silicones

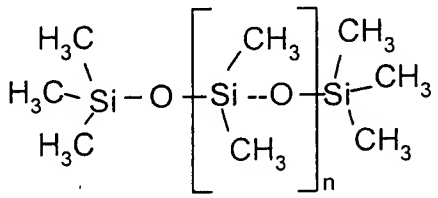
- Polymerization:



- Equilibrium mixture of cyclics and linears
  - High Mw linear polymer
  - Typically 11-18 wt. % cyclics for PDMS
- Low molecular weight species are very volatile and low viscosity

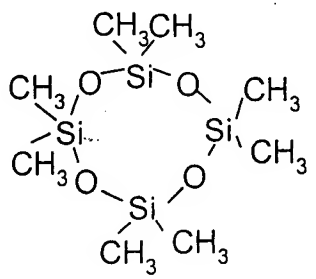
Low Mw Silicones

Compound	Viscosity @ 25 C cS	Boiling Point C	Mw
Water	1.0	100	18
MM	0.7	101	162
D_3		135	222
MDM	1.0	153	237
D_4	2.3	175	297
MD_2M	1.5	196	311
D_5	3.9	211	371
MD_3M	2.1	230	385
D_6	6.6	245	445
MD_4M	2.6	260	459
D_7	9.5	276	519
MD_5M	3.2	287	533
D_8	13.2	303	593
MD_6M	3.9	310	607
D_9	18.0	326	667
MD_7M	4.5		681



M $(D)_n$ M

Linear series

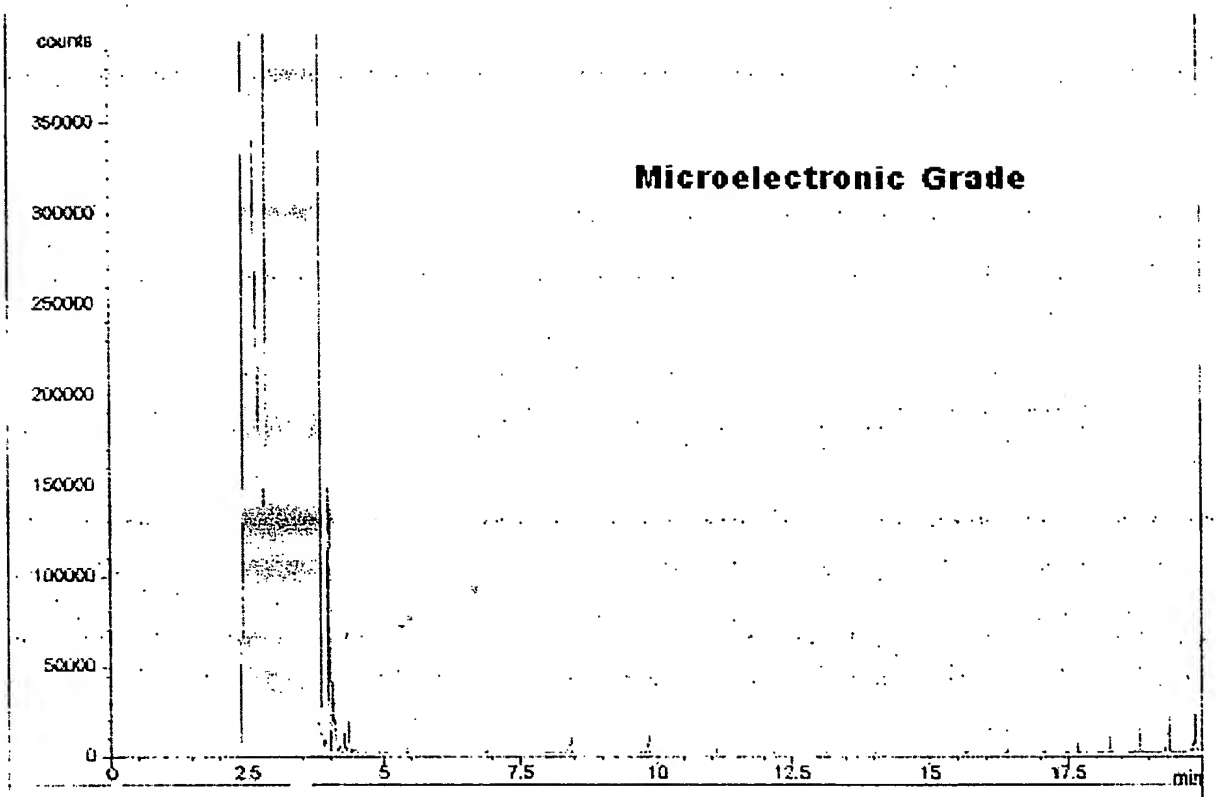


D_4

Cyclic series

Removal of Low Mw Species

- Vacuum strip dependent on:
  - time, temperature, vacuum level
- Liquid-liquid solvent extraction
- Non-solvent precipitation
- Super critical fluid extraction
- High pressure liquid chromatography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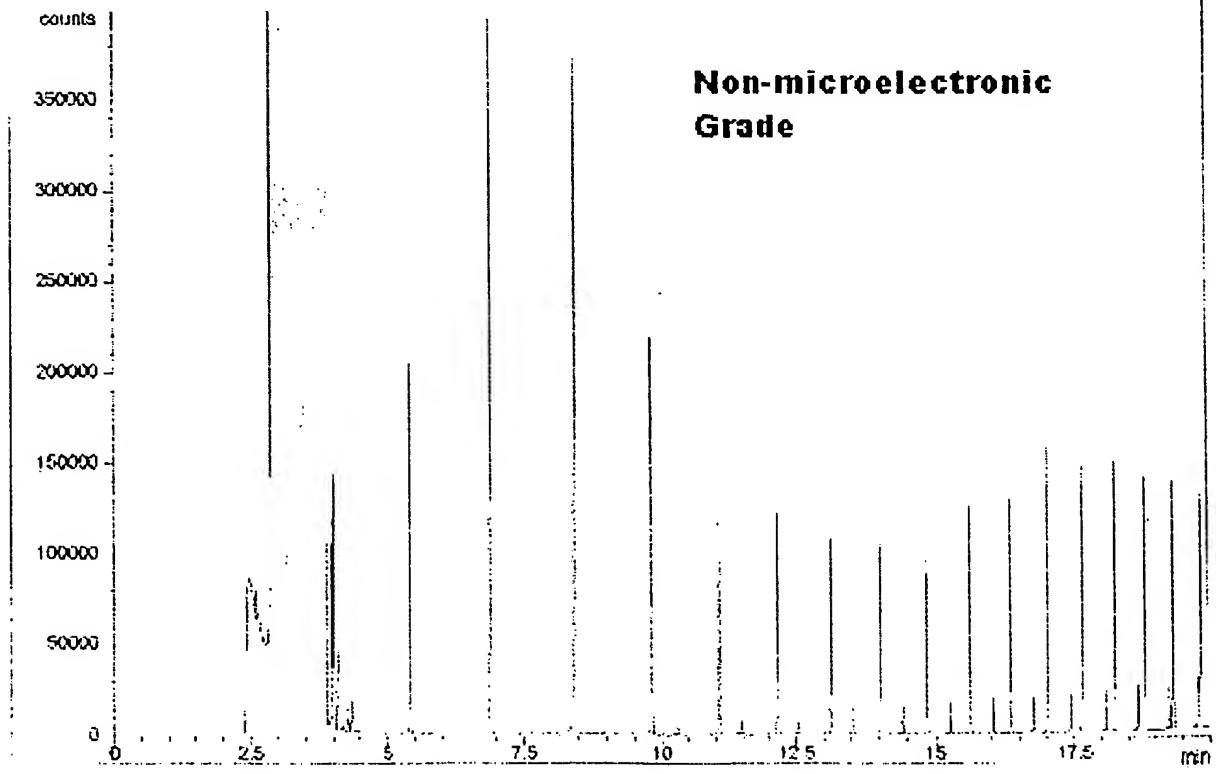
350000
300000
250000
200000
150000
100000
50000
0
0
2.5
5
7.5
10
12.5
15
17.5
min
Microelectronic Grade


counts
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5
7.5
10
12.5
15
17.5
min
Non-microelectronic Grade

Gas Chromatography

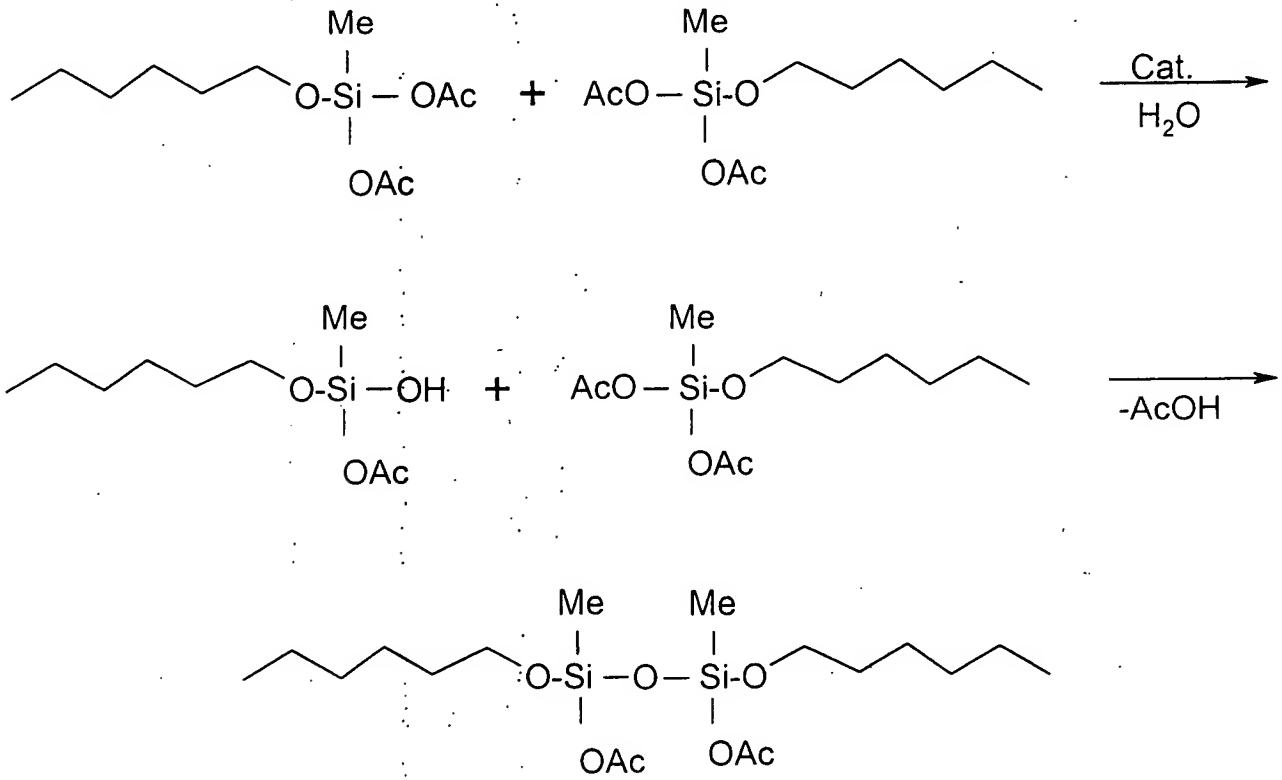
Compounds	Non-microelectronic Grade	Microelectronic Grade
	PPM	PPM
D4-D12	20600	0
D13-D20	11860	734

- Greater than 95% reduction in low Mw species
- Remaining material is high Mw
  - high viscosity & high boiling

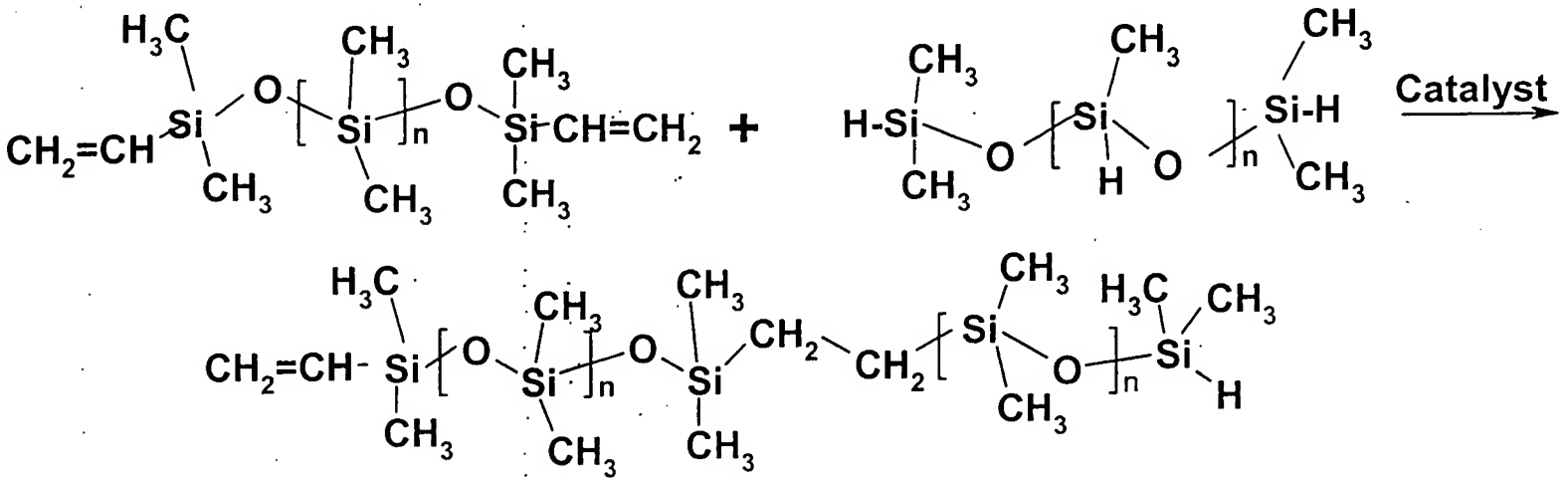
Typical Silicone Formulation

- Silicone polymer
  - outgassing
- Filler
- Crosslinker
- Adhesion promoter
- Catalyst (Pt)

Condensation Cure

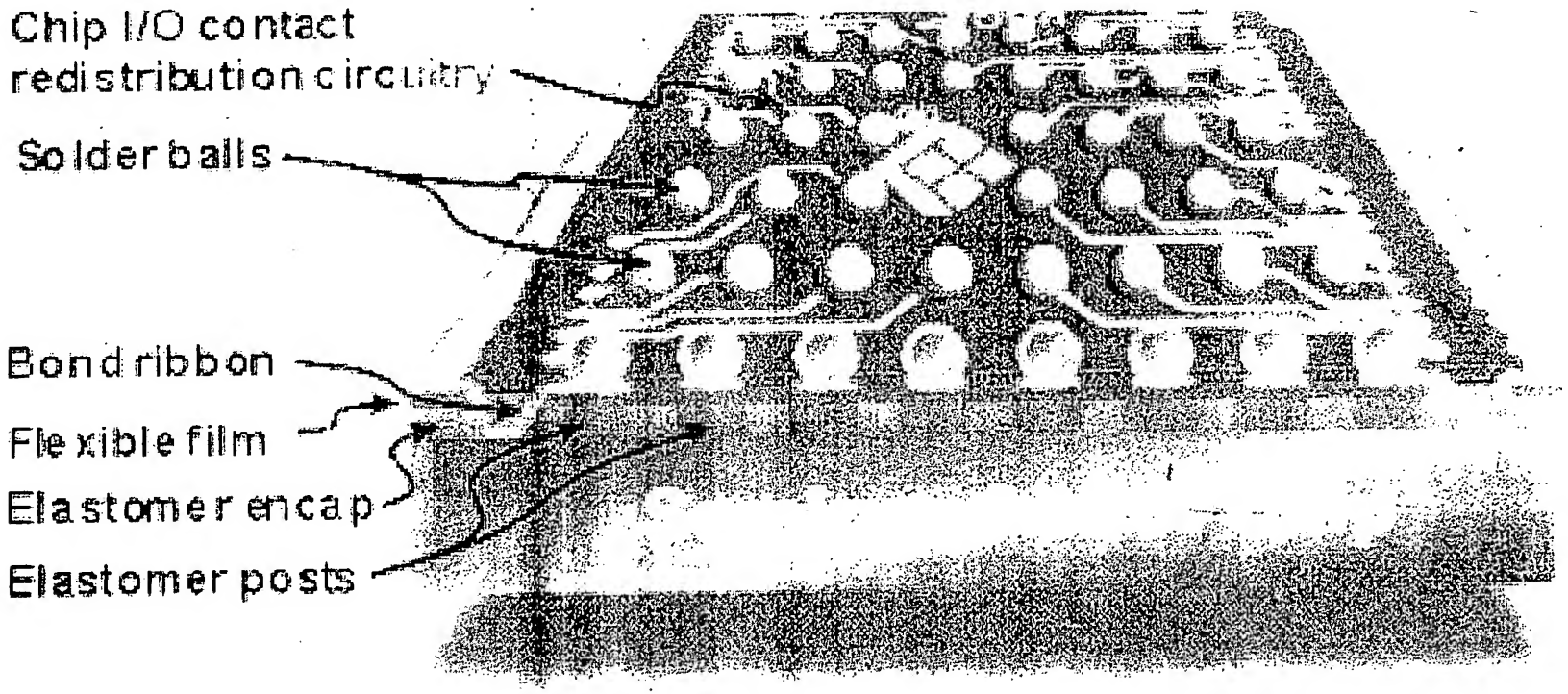


Addition Cure



- No cure by-products
- Heat activated
- Can be 1-part or 2-part

µBGA Package



Material and Process Considerations for CSP Lead Bonding

- Design considerations
  - Nubbins or pads
  - Proximity to lead bond area
- Material considerations
  - Rheology
  - Low volatility
  - Low creep
- Off set stencil printing
  - Gross contamination during printing
  - Time between print and cure

Non-microelectronic grade materials led to:

- Migration of silicone onto leads
  - Cure silicone nubbins
  - Self diffusion of low Mw components
    - $D \alpha 1/Mw^2$
  - Surface spreading
    - $\eta \alpha Mw$
  - Outgassing

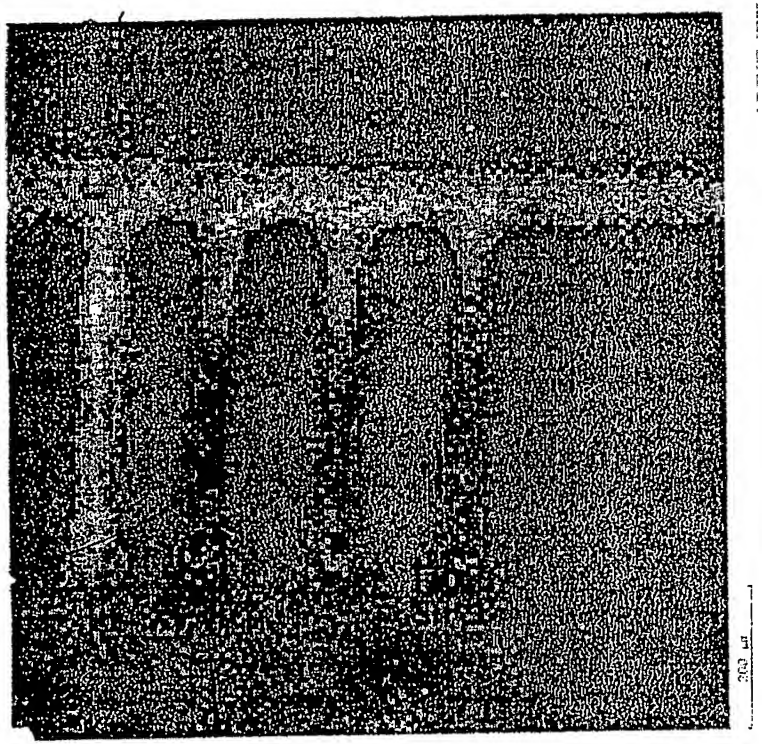
Use of non-microelectronics grade silicones led to increases in:

- Lead bond ultrasonic frequency
- Cleaning frequency of lead bond tip
- Deformation of the lead
  - High failure rate due to heel breaks

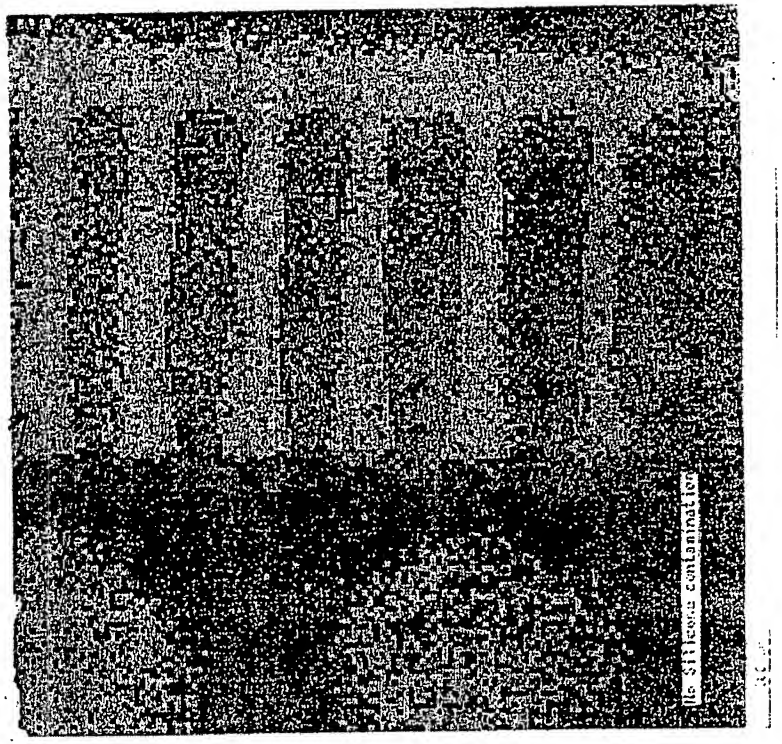
Microelectronics grade silicone material eliminated all problems:

- Increased yield
- Increased productivity
- Increased reliability

XPS of TAB tape showing leads



Non-Microelectronic Grade Silicone



Microelectronic Grade Silicone

Summary

- Silicones have unique properties due to their chemical composition.
- Equilibration polymerization of silicones
  - Low Mw species present - root cause
  - Can be removed by further processing
- Not all silicone materials are alike
- Low outgassing microelectronic grade silicone material set is commercially available.
- Companies are in production with μBGA using a low outgassing silicone material set.